Partners In Technology

Research collaboration between NASA and a major non-aerospace company exemplifies the benefit potential of aerospace technology transfer

In 1837, a pioneer blacksmith named John Deere perfected the steel plow and founded a company to manufacture farming equipment. Today, Deere & Company is the world's largest producer of farm implements and a leading manufacturer of equipment used in construction, forestry, landscaping, materials handling and other fields. Headquartered in Moline, Illinois, the company employs some 50,000 people, manufactures 600 different products in the U.S. and nine foreign nations, and sells them in more than 100 countries at the rate of about $4 billion annually.

A major reason for Deere & Company's success is its firm commitment to research and development, funded in recent years at an average of better than four cents for each sales dollar—which means an annual investment approaching $200 million. Like the company itself, R&D is highly decentralized; each factory is responsible for developing its own product line. All of the factories are served by the John Deere Technical Center in Moline, which conducts advanced research toward new technology that may eventually be incorporated in the products of the various divisions. Aerospace technology is playing an important part in the company's research effort; Deere's Technical Center is working with NASA in a broad technical interchange program, exploring avenues of aerospace research that promise product improvements.

NASA and the company are cooperating in about a dozen different areas of research. In some instances, cooperation takes the form of Technical Exchange Agreements, wherein NASA and Deere share information, facilities and expertise and jointly conduct research, testing and evaluation. In other cases, NASA and the company are cooperating informally; Technical Center scientists visit NASA field centers, consult with NASA experts in various fields, study reports of aerospace projects and acquire information about new techniques, procedures, materials and other advances originating in aerospace programs. It helps Deere & Company's researchers fill gaps in their knowledge, avoid research "dead-ends," and identify promising new lines of investigation. And it's a two-way street: NASA benefits from interaction with non-aerospace scientists whose objectives are different and from knowledge of the company's own extensive R&D, thus expanding NASA's horizons and suggesting ways by which the agency might broaden and accelerate its transfer of technology to the non-aerospace community.

One example of NASA/Deere collaboration involves experiments in processing materials under near-zero gravity conditions, a burgeoning technology that promises extraordinary benefits in orbital manufacture of products that cannot be made on Earth due to adverse influences of Earth's gravity (see page 00). NASA and several industry firms are performing low-gravity research

Shown above is a four-wheel drive tractor, at upper right a combine harvester and at lower right a grader, equipment representative of the broad product line of Deere & Company. Deere scientists are working with NASA in a multifaceted technical exchange program, investigating areas of aerospace technology that might be applied to the company's products.

aboard the Space Shuttle, in aircraft—where low gravity can be experienced for a few minutes—and in ground-based simulations. Although Deere & Company is not planning to manufacture products in space, it is using the low-gravity environment as a research laboratory, studying what happens to iron as it is melted and solidified in aircraft-borne furnaces.

Cast irons account for about 25 percent of the weight of John Deere products. Therefore, anything Deere & Company can do to improve the strength, quality or producibility of cast irons is very important to Deere and its customers. The strength, castability and machinability of cast irons is highly dependent on the shape of the graphite within the steel matrix. The low-gravity environment provides an opportunity to study the formation of graphite from a new perspective. Deere & Company is currently concentrating on studying the "diffusion phenomenon," where carbon atoms move in the molten iron as it solidifies and form various shapes from spheroids to thin flakes; knowledge of how and why this happens can lead to new Earth processing techniques for producing improved, more economical castings. Deere & Company learned a great deal from experiments in a furnace developed by Marshall Space Flight Center, flown aboard a NASA aircraft that achieves near-zero gravity for very short periods. That research showed promise and the company is now planning long-duration experiments aboard the Space Shuttle with an advanced furnace capable of accommodating larger samples.

Another example of joint effort is the Stirling engine, an external combustion type of engine being investigated by NASA (Lewis Research Center) and the Department of Energy as an alternative propulsion system for road vehicles. The Stirling engine offers a number of advantages, chief among them lower fuel consumption and the ability to use a wide range of fuels. Deere & Company is interested in the Stirling's potential as an alternative to the diesel engines currently manufactured. Under a Technical Exchange Agreement, Deere is conducting controlled laboratory tests of the Stirling, seeking to increase power output and overall efficiency. Under the

agreement, NASA furnishes the engine, parts and certain services; Deere conducts testing and analysis and shares the results with NASA. This project is an excellent example of the sharing aspects of NASA/Deere collaboration: Deere & Company is able to explore a technology of interest with a reduced investment and NASA benefits from the results of the company's investigations, which supplement and broaden the data being gathered by Lewis Research Center.

Deere & Company is interested in another area wherein Lewis has extensive expertise: use of ultrasonics to measure the properties of materials for non-destructive testing. Lewis and Deere researchers are working with a committee of the American Foundry Society that is making a detailed study of the mechanical properties of graphite iron; they plan to make a comparison of property measurements acquired by the NASA ultrasonic procedure and by conventional destructive tests. If they find a good correlation, the NASA technique would be highly beneficial—not only to Deere & Company but to the entire foundry industry—as a way of reducing the cost of testing production castings and allowing quality checks of *all* production castings, which obviously cannot be accomplished by destructive tests.

This collaboration between a government aerospace research agency and a major non-aerospace manufacturer exemplifies a different form of the aerospace spinoff process. In the traditional type of spinoff, technology originated to meet aerospace needs is reapplied by industrial firms to create an innovative product or process. Such product spinoff seems likely to result from NASA/Deere cooperation, but in this instance Deere & Company is not simply reapplying technology already available but actively participating in the development of technology, using its own extensive R&D capability to complement NASA's efforts, adapting NASA information to new research paths and providing feedback of importance to NASA's own work.

One of the world's largest manufacturing businesses, Deere & Company produces agricultural tractors, combine harvesters, tillage and planting tools, hay and forage equipment; industrial equipment such as crawler tractors, loaders, motor graders, scrapers, excavators and materials handling tools; and a line of lawn and garden tractors and attachments. A highly integrated firm, Deere & Company also makes most of the components used in assembly of its products—engines, transmissions, castings of all types, hydraulic cylinders, even nuts and bolts.

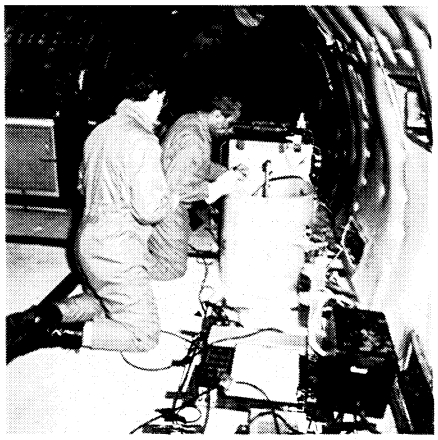
To maintain competitive status over such a broad product line, Deere & Company conducts research and development over a very wide spectrum at its John Deere Technical Center, its Product Engineering Center in Waterloo, Iowa, and each of its many manufacturing plants. Some 3,500 people, backed by an array of sophisticated facilities, are engaged in R&D programs. One phase of the company's R&D involves active collaboration with NASA in a number of research activities, with the goal of adapting aerospace technology to the John Deere product line and to the processes by which these products are manufactured.

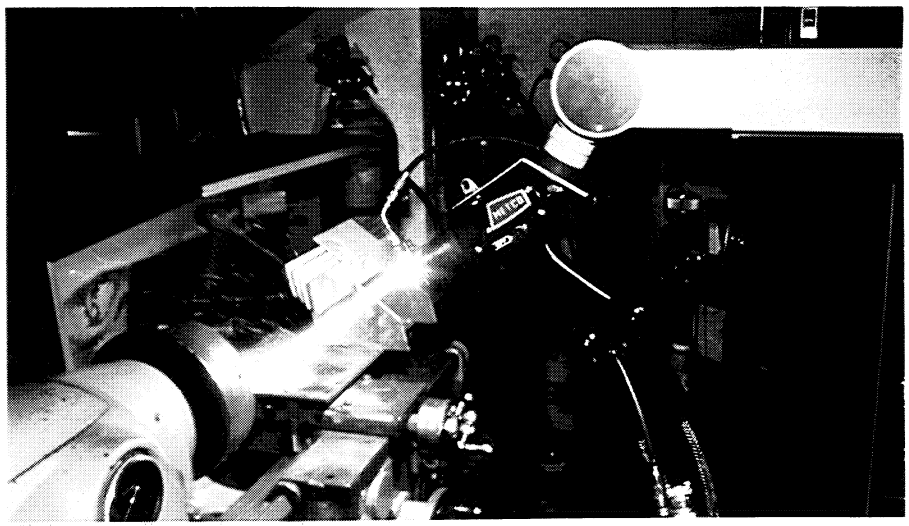
In addition to experiments in low-gravity materials processing, advanced propulsion and ultrasonic testing (see page 53), NASA/Deere technical interchange extends to these areas:

Composite Materials. With help from Langley and Lewis Research Centers, Deere & Company is exploring the possibility of substituting fiber reinforced plastic composites or metal composites for certain mechanical components of John Deere equipment. For example, metal composites capable of withstanding very high temperatures are being investigated for applications in diesel engines, where operating temperatures are so high that existing materials are limiting factors on horsepower and fuel efficiency.

Ceramics. Contacts with scientists and engineers at several NASA centers, and with NASA contractors who developed technology for the Space Shuttle's protective ceramic tiles, provided Deere & Company a knowledge base that resulted in a company decision to set up its own ceramic research facility. Deere

Below left, NASA and Deere technicians aboard a KE-135 research transport demonstrate weightlessness as the aircraft flies a parabolic curve to achieve near-zero gravity for brief periods. Deere & Company has conducted metal casting tests under low gravity conditions. In the photo below, technicians are conducting an experimental "pour" of a molten iron sample during a moment of low gravity, their feet strapped to the floor to keep them from floating.





Ceramic research is one area of NASA/Deere cooperation; Deere is testing ceramics to determine their impact on the drag and wear resistance of tillage equipment. Here a robotic arm is spraying hot ceramic onto a tool at the John Deere Technical Center.

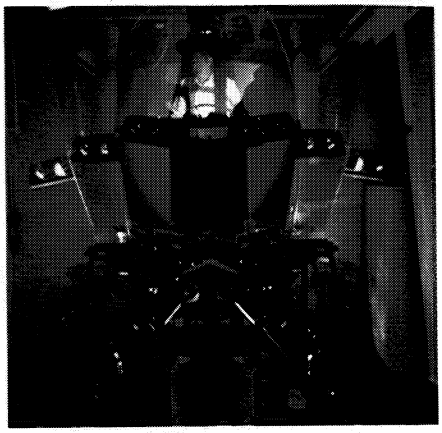
scientists are studying ceramics toward their possible use as insulating material for high temperature engine parts or perhaps for making some parts entirely of ceramics.

Wear and Lubrication. NASA centers, particularly Lewis Research Center, have provided Deere researchers considerable information on parts wear and advanced lubrication materials and techniques, helpful in company studies of gear wear and protective measures. Although NASA information reflects aerospace interests, it has been found to be readily adaptable to company research on its own problems.

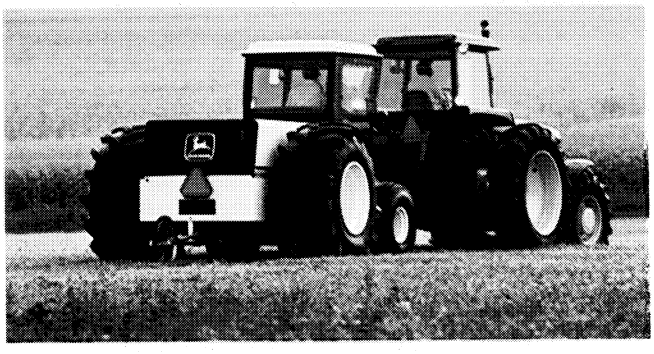
Plasma Coatings. Lewis is conducting extensive research on plasma coatings, used as anti-corrosion protection for aircraft turbine engine parts operating in an extremely hot environment. A visit to Lewis by Deere scientists, and follow-up contacts with NASA personnel, provided the company a wealth of information on techniques for depositing and testing plasma coatings. Lewis' assistance was instrumental in a company decision to create its own laboratory to explore developments in this area. Plasma coatings are being considered as protective shielding for components of farm implements subjected to high-wear environments, such as ground-engaging tools and parts of machines over which hay and grain slide.

Sensors and Electronics. One Deere & Company target is development of simple, inexpensive sensors for determining the depth of an implement in the soil. The company is also interested in sensors and computer programs for robotic welders and manipulators used in the manufacturing process, and in high reliability electronic devices for a variety of applications. Company research in these areas has benefited from information supplied by Marshall Space Flight Center and Jet Propulsion Laboratory.

The NASA/Deere relationship is broader than, but representative of a number of similar arrangements between NASA and industrial firms. Through several different types of cooperation mechanisms (see page 119), NASA seeks to effect broader direct transfer of aerospace technology—as well as indirect secondary applications, or spinoff—in the interest of U.S. productivity.



In Deere's new human factors laboratory, engineers study how vibration and noise can affect the performance of a vehicle operator.



The Dyna-Cart (above) was developed by Deere engineers to help them measure the effects of ballasting, tire slippage and other factors on fuel efficiency. Technical Center scientists are also studying the properties of alternative fuels (right) that may power future products.